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ABSTRACT

This study examined the educational outreach efforts of the National High Magnetic Field Laboratory (NHMFL) at its main facility at Tallahassee, Florida. The NHMFL is a federal-state partnership; its primary purpose is to provide the tools and resources to conduct research using high magnetic fields. It provides links among educational stakeholders and furnishes resources in the form of materials and expertise as it influences policy on various levels. The analysis here builds on the premise that a science research institution can facilitate reform and enhance science education by involving various members of the community. Data were gathered by distributing three separate surveys at NHMFL events, such as the NHMFL Annual Open House, the Ambassador Program, K-12 web site, and in-house and school-based outreach efforts. The data were reviewed based on three perspectives: the sociological, the educational, and the political. The results confirm that a science research institution can facilitate reform in education by involving stakeholders, by fostering links among stakeholders, by providing resources in the form of materials and/or expertise, and by influencing policy. (RJM)

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THE SCIENCE RESEARCH INSTITUTION: A NEW MODEL FOR EDUCATIONAL REFORM THROUGH COMMUNITY INVOLVEMENT

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INTRODUCTION/PURPOSE

In this paper we present the design of our study followed by a discussion of the results and our conclusions. The results are presented organized by the four agents of reform: (a) involving stakeholders; (b) providing links among stakeholders; (c) providing resources; and (d) influencing policy. We present examples of how the National High Magnetic Field Laboratory (NHMFL) accomplishes each agent and provide possible implications for each example.

The purpose of this paper is to document how the National High Magnetic Field Laboratory involves stakeholders, provides links among the identified stakeholders, provides resources in the form of materials and expertise, and influences policy on a number of levels. Not only are these four aspects of educational reform considered but how they influence stakeholders in educational reform is addressed as well. Stakeholders in educational reform have been identified as students, parents, the general public, classroom teachers and other educators, policymakers and politicians, and business leaders. The literature on educational reform supports the contention that all identified stakeholders have an interest in, and an affect upon, efforts to reform teaching and learning

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(Carnegie Forum on Education and the Economy, 1986; Murphy & Hallinger, 1993; Papagiannis, Easton, & Owens, 1992). The connection between science institutions which, until recently, have been considered remote organizations beyond the grasp of the citizens who benefit from their products, has not been considered prior to this study.

In order to accomplish the goal of involving all educational stakeholders, it is necessary to create and run a program that impacts all levels of education. Such a program exists at the National High Magnetic Field Laboratory (NHMFL), a consortium of the Florida State University, the University of Florida, and Los Alamos National Laboratory in New Mexico.[1] Through its K-12 Educational Programs, the NHMFL engages a variety of stakeholders by providing links which allow them to take ownership and see that what is accomplished in a science research institution is "do-able." This study examined the educational outreach efforts of the NHMFL at its main facility located at Tallahassee, Florida.

BACKGROUND

Educational decentralization and restructuring, as a key educational reform, creates opportunities and conditions to mobilize current and new stakeholders in efforts to improve equity and quality in educational improvement. Not only students and teachers, but parents and other community members, need to share the excitement found in the growing numbers of science-based work environments. It is this excitement, combined with information and knowledge about the occupations found in them, that affects their institutional structure

Science institutions which, until recently, have been treated as "remote" organizations beyond the grasp of the citizens who benefit from their products, can

[1] The educational outreach efforts are coordinated by the host institution.

transform a community's science perspective. That perspective can serve as a bridge that brings together a community in appreciation of its institutions and motivates children and parents to master the concepts and skills required by such workplaces. This motivation translates eventually to the classroom itself. In this study, we demonstrate how a science institution can facilitate reform in education by (a) involving stakeholders; (b) providing links among stakeholders; (c) providing resources; and (d) influencing policy.

The NHMFL is a unique federal-state partnership supported by funds from the National Science Foundation and the State of Florida and operated by the Florida State University, the University of Florida and Los Alamos National Laboratory in New Mexico. The primary purpose of this user facility is to provide the tools and resources to conduct research using high magnetic fields. Compared to the other nine high field laboratories in the world, the NHMFL is the largest and highest powered supporting the highest fields possible in an accessible facility. Scientists from all parts of the world come to the facility to conduct both long and short-term research in fields that include biology, chemistry, physics, geochemistry, geology, medicine, and environmental sciences.

The K-12 Educational Programs component is an important part of the mission of the laboratory and takes this mission to mean that education does not begin and end with students in classrooms, but extends to include teachers, the general public, and the scientists who work at the laboratory (henceforth to be called stakeholders). K-12 Educational Programs believes that by engaging a wide variety of stakeholders, we can provide links that encourage them to take ownership of the science research facility in a variety of ways that will be described in this paper. This sense of ownership integrates stakeholders into educational reform efforts and translates into changes that ultimately affect the classroom.

The study builds on the premise that a science research institution can facilitate reform by involving various members of the community in enhancing science education. "[F]inding practical ways to increase the meaningful participation of everyone involved in the educational experience, including parents, local residents, and especially students themselves" (Apple & Beane, 1995, p. 101), can be done by involving all educational stakeholders in a program that affects all levels of education.

This paper documents both formal and informal learning that takes placed in a nontraditional science education facility, namely the NHMFL. Informal science education refers to learning scientific ideas outside of the classroom. It infers a relationship between the learner and the source of site of learning and has been described as a type of learning that is unplanned, unorganized, learner-centered, done in groups, of short duration, done by choice, uses nontraditional media, and is not usually evaluated. It is an area sometimes overlooked when educators consider school or curriculum reform and yet the literature indicates a growing concern with providing experiences for students that extend beyond the formal classroom setting (Ramey-Gassert, 1997; Apple & Beane, 1995; Eisner, 1994; Wellington, 1990; Lucas, 1991). These experiences have characteristics that engage students in different ways because informal settings imply that learning is voluntary, not evaluated, offers nonverbal experiences, multimedia displays, and a more flexible, nonconfining environment.

Research has tended to evaluate programs that are structured; programs that have structured activities, times, identified information that is to be transmitted. Evaluation of these kinds of programs does not go further than determining if the specific information was transmitted. Price and Hein (1991), however, recommend that staff of museum programs be educated in pedagogical issues that support questioning, curiosity, inquiry,

and participation to facilitate a blending of informal environments with formal teaching and learning. There is more to informal education than the transmittal of knowledge; attitudes toward science and the culture of the scientific enterprise can also be transmitted in ways that are far more subtle than organized, structured tours or programs. Whether intended or unintended, consequences of interacting with informal educational institutions can have far-reaching implications for educational reform as the science research institution provides links among stakeholders that facilitate reform.

RESEARCH STRATEGY

This descriptive study was completed using data analyzed from artifacts generated by the following events, materials, and programs that are described in the Results section: NHMFL Annual Open House, Ambassador Program, K-12 web site, in-house and school-based outreach, tours, elementary and middle school teacher workshops, statewide "training-the-trainer" workshop, school/community organization partnerships, involvement in community events, school events, mentorships and externships/internships, business partnerships, legislation reports and meetings, State Department of Education collaborations, County School Board collaborations, national/international recognition, university courses, and internal NHMFL reports and documents. Artifacts included drawings by students both before and after visits to the NHMFL and drawings pre and post outreach; interviews with representatives from each stakeholder group; evaluations of statewide and local workshops; surveys administered at public functions; samples of student work; surveys of teachers using curriculum materials; and classroom observations. Artifacts were reviewed for evidence and examples of how the NHMFL (a) involves stakeholders; (b) provides links among stakeholders; (c) provides resources; and

(d) influences policy. Interrater reliability was achieved by having at least two researchers independently categorize the data. We compared our categorizations and, where there were discrepancies, we discussed the data until we reached agreement.

Data

The researchers gathered data to ascertain stakeholders' meanings and interpretations constructed from interacting with the National High Magnetic Field Laboratory through the activities described above. This was done by analyzing (1) surveys; (2) interviews; and (3) artifacts.

Surveys. Three separate surveys were distributed in conjunction with NHMFL events. As the most frequently used method for observing and gathering data (Babbie, 1998), surveys were used in order to accumulate a large amount of data for this descriptive study. Respondents included teachers, the general public, and teacher trainers.

The NHMFL Open House Survey was administered at an annual event that is preceded by publicity designed to attract as many people representative of the community at large as possible. The one-day event had over 3,5000 visitors to the laboratory. Families, students, out-of-town visitors, and members of the North Florida community toured individual laboratories, saw videotapes, used computers, and interacted with NHMFL personnel, displays, demonstrations, and activities. As people entered the laboratory, they were asked to fill out a self-explanatory survey that attempted to get a snapshot of what people in the community did and did not know about the laboratory and the people that work there. This survey was expected to shed light on the issues of involving stakeholders and providing links among the stakeholders. Beginning with whether or not respondents had ever been to this particular science research facility or others like it, the questions

ranged in scope from what the expectations were for what the respondent would see inside to whether the respondent could envision herself/himself working at the NHMFL.

One category that was used for this particular survey was "can picture yourself working at the NHMFL." Surveys were sorted by those people who could picture themselves working at this science research facility and those that could not. For example, answers ranged from a simple "yes" or "no" to "possibly" or "Yes, but I don't think I have a strong enough science background." The answers that disclosed a respondent's perception of his or her own perceptions of what kind of people work at a science research facility were categorized (b1) and the yes/no/possibly answers were coded (a1).

The second survey instrument we analyzed consisted of self-administered questionnaires distributed at the end of each of four workshops for teachers. In the hope of going beyond providing resources for educators and involving this particular stakeholder group, the researchers hoped that positive reactions on the survey instrument would influence professional development policy as the NHMFL became an integral part of professional development and continuing teacher education at the county and state level. These questionnaires ranged in scope from asking how teachers would use what they learned in their classrooms to a discussion of the use of a science research facility as an educational resource. In an effort to provide links among stakeholders, respondents were asked to identify ways to promote collaboration among local and state agencies and the NHMFL.

For example, in response to a question on how the NHMFL can better assist teachers in enhancing science teaching and learning in their classrooms, answers ranged from offering "field trips and outreach" to "provide curriculum materials." Researchers categorized these questionnaires by those activities that are already offered by K-12

Educational Programs (coded c4) and those that are new offerings (c3). The responses were further sorted by determining which of the educational programs that are offered at this time will continue to be available to teachers and students (e.g., teacher resource room coded b2) and those that will not (send representatives to faculty meetings at all county schools); additionally, the activities that are not offered at this time were sorted into those that were feasible for K-12 Educational Programs to offer in the future (e.g., more workshops on specific topics, coded c3) and those that were not (a notebook of recipe-type lessons for primary teachers, not coded).

A third survey was mailed to educators who participated in a workshop linked to a particular curriculum product. Along with information on how the product was being used in individual classrooms, there was an effort to get information on the types of policy decisions made at the school level that influence how teachers use resources. Results of this survey also attempted to determine how providing resources as well as involving stakeholders in the development, design, and implementation of resources facilitates educational reform. Surveys were mailed to each participant at their school with a self-addressed stamped envelope to encourage a high rate of return. Workshop participants were sent a copy of a photograph as a "souvenir" incentive to return the form.

All respondents were positive about using the product in their classrooms indicating that the materials were "teacher friendly" (coded c1), "obviously created by teachers" (coded d1), and "took into consideration standards and benchmarks" (c3). These surveys were categorized into those that mentioned schoolwide policies that affected how the product was used in the classroom (e.g., "good for interdisciplinary team use" or "difficult to implement for a new teacher").

Interviews. A series of personal interviews were conducted to elicit feedback from the following stakeholder groups: students that participated in an in-house outreach and tour, students participating in a mentorship program, business partners, scientists, teachers, parents, and community members. Interviews were conducted by the researchers using a set of questions that were designed to elicit responses about the interaction between the NHMFL and the interviewee and how this interaction affects perceptions of science and scientists. Each potential participant was provided with a consent form prior to the interview date; the form indicated the researchers' intention to audiotape the interview to be transcribed later. It also gave the researchers permission to use the data future publications.

Respondents were given a checklist of ways in which they might have interacted with the laboratory; this helped identify for both the interviewer and interviewee the ways in which the NHMFL might have had an influence on behavior or thinking. Five open-ended questions were posed to each respondent. The interviewers used a series of prompts to elicit as much information as possible. Probing to clarify answers was done by the interviewers in an attempt to obtain answers that were complete and coherent. Two interviewers were present at most sessions to ensure neutrality of the prompts and to enhance interpretation of answers.

Responses were categorized into those that dealt with education in particular, those that discussed science and scientists, and those about the facility itself. For example, "Get young people here and get their minds turning" (coded a5) or "I have a chance to do science stuff that I can't do at school" (a10). Student responses about scientists reflected a change in their view of people who work in the sciences (e.g., "Scientists don't all wear white coats and work with test tubes" and "Not all people who work at the NHMFL are scientists," coded b14). Lastly, in the category of the facility, comments revealed a great

deal about how the NHMFL can "give teachers another tool to prod young minds" or "when people don't understand what's going on there, they think this is some kind of nuclear place with guided missiles out back. People should see that scientists are not mysterious people who work behind closed doors" (b14).

Artifacts. Lastly, researchers analyzed artifacts from a variety of sources in an attempt to link the laboratory with each of the four aspects that facilitate educational reform. Samples of student work, letters from students and parents, the NHMFL Annual Report, the "MagNet" (an internal newsletter), newspaper articles, workshop evaluations, web site logs, curriculum surveys, and reports for outside agencies.

For example, a newspaper column on opportunities for teachers was coded d2 when it mentioned grant opportunities for teachers at the NHMFL. Web site logs that revealed worldwide interest in the NHMFL, based on the Ask An Expert site, with questions such as "How do scientists measure magnetic fields," were coded c2. A report that was done for the Higher Education Consortium was coded d3 because it described to an outside agency the curriculum development and training implementation functions of K-12 Educational Programs.

Analysis

Data were reviewed based on three perspectives. From the sociological perspective this research looked at what meaning members of the various stakeholder groups generated of the NHMFL and science in general. Additionally, we examined the impact of various educational and promotional activities of the laboratory on those meanings. From the educational perspective, this research looked at teaching and learning from a constructivist point of view. What students and teachers are learning, how teachers are facilitating that learning, what members of the general public are learning about the laboratory and science,

and what members of the NHMFL are learning. The political perspective (which we mean to encompass policy and organization) looks at internal politics at a research facility, local and regional policy, and national policy related to the development and implementation of K-12 Educational Programs. Each of these perspectives provides insight into how a science research facility involves stakeholders and allows each one to take ownership in such a way as to encourage educational reform. Familiarity with the NHMFL provides a sense of comfort which promotes identification with those that work there.

Each set of data (surveys, interviews and artifacts) was categorized by how it reflects the factors that facilitate educational reform: (a) involving stakeholders; (b) providing links among stakeholders; (c) providing resources; and (d) influencing policy. Once the data were categorized, themes were identified within each of the agents (a-d). Outliers were noted and placed into a miscellaneous category. Researchers provided multiple readers categorizing datasets and developing themes. Discrepancies were discussed before outliers were considered "miscellaneous" and examples of each of the four factors that could not be agreed upon were discarded. Only examples that had interrater agreement were used in the analysis. All examples cited in this paper met that criteria.

RESULTS

Based on the analysis of data, evidence exists that supports the claim that a science research institution can facilitate reform in education by: (a) involving stakeholders; (b) providing links among stakeholders; (c) providing resources in the form of materials and/or expertise; and (d) influencing policy. Furthermore, stakeholders' meanings of the laboratory doing the above-mentioned Results are reported in the following manner. Each

of the four factors influencing educational reform is addressed and the examples of evidence that the factor is addressed by programs at the NHMFL are listed. Examples are accompanied by a brief description and an appropriate sample from the data.

(a) Involving stakeholders. The term stakeholders is used to describe the identified groups that are influenced by events and programs at the National High Magnetic Field Laboratory. Stakeholders include students from pre-K to postdoctoral level, teachers and educators from preK-post doctoral level, parents, politicians and policymakers, business leaders, and the community at large. Evidence was collected that supports the researchers' beliefs that when the stakeholders are involved in any way with the laboratory, their beliefs and conceptions of science and scientists change and with that change comes a sense of ownership of the NHMFL. The following events or programs involved a variety of stakeholders.

a1. The 1997 Annual Open House. Each year, in an effort to involve community members, the NHMFL conducts an open house at which scientists and researchers and NHMFL personnel interact with members of the community to share the kinds of research being done at the laboratory. It is also a chance for the public to talk with members of the scientific community in an attempt to bridge the gap between the two and to demystify the work of scientists. Over 3,500 visitors attended the 1997 Open House. The 1-day event attracted families, students, out-of-town visitors, and members of the North Florida community. As visitors toured the individual laboratories, saw videotapes, used computers, and interacted with displays, demonstrations, and activities, they were surveyed by the K-12 Educational Programs staff. The overwhelming result of the survey was the realization that many community members do not know what the NHMFL is, what kinds of people work there, and what its role is in the community. Quite a few survey

(a) Involving stakeholders (continued)

responses indicated surprise that it was not more like Seaworld or Disneyworld. Getting the point across that the NHMFL is a science research facility, not an entertainment facility, that only opens its doors in this way once a year was difficult. Others recognized that serious, sophisticated work is done at this facility, but preferred to be entertained rather than informed. The majority of respondents had never been to the facility before and most had no idea of the types of research that could be done using high magnetic fields. The fact that the NHMFL is the largest facility of its kind in the world came as a great surprise to many respondents, as they realized that the laboratory is a source of great pride within the community. Most respondents stated that there should be ongoing involvement with all levels of education; the link between the laboratory and careers in science was stressed in a number of surveys. Several respondents thought that the lack of knowledge about what is done at the laboratory was a deficiency on their part, either because of their education or personal shortcoming. The majority of respondents indicated that science facilities that are not designed to be "attractions" could play a role in public education.

a2. Ambassador Program. Twice each year, educators and representatives from organizations that support education gather at the NHMFL. The Ambassador Program was developed to create a network of educators and a partnership between education at different levels. Pulling from a three county area, teachers from all levels meet with community representatives and the NHMFL K-12 Educational Programs staff to identify ways that the laboratory can support classroom teachers and enhance teaching and learning. Results of the meetings have translated into curriculum products on magnetism, a series of workshops for primary, intermediate, and middle school teachers, a pre/post packet of information and activities sent to teachers before tours, expanded hours for the Educational Resource

(a) Involving stakeholders (continued)

Laboratory, discussion rooms on the web site, activities for students and teachers posted on the web site, and an activity book for primary students.

a3. Web site. K-12 Educational Programs has a multifaceted web site that is aimed at both students, teachers, and the general public. It offers not only an overview of the facility but a virtual tour that gives a detailed look into research areas and individual laboratories. The web page offers a number of activities for use at home or at school, a discussion room for educators and community members to discuss current issues in science and science education, and an Ask An Expert site at which questions about magnets, magnetism, and science in general, can be sent directly to the NHMFL to be answered by appropriate scientists and laboratory personnel. Web site feedback provides a global look at the impact the facility is having in classrooms with questions and submissions coming from local, national, and international locations. In the past year, hundreds of people of all ages from the United States, Canada, South Korea, the Netherlands, India, Mexico, Argentina, Australia, Greece, Hong Kong, and Singapore have accessed the site. Data are included as evidence that a technological constituent is compatible with current reform efforts.

a4. Outreach Programs. Over 10000 students, teachers, and members of the general public across the State of Florida as well as in South Georgia, have interacted with the NHMFL through outreach programs in one of two ways. In-house outreach includes activities done at the facility with K-12 Educational Programs personnel. Other outreach programs are offered at the school or classroom site and are done with either small or large groups. The emphasis of these programs is on science and scientists with the goal of altering how schoolchildren perceive them. What scientists do and how they look are

(a) Involving stakeholders (continued)

questions that students tend to answer with limited experience. The outreach programs are designed to not only deal with magnets and magnetism but with science as a discipline that is approachable by all students and one that could possibly be a career goal for many students. An analysis of student artwork showed a difference between drawings of "someone doing science" before the outreach program and those done after a program. Students' conceptions of science and scientists changed markedly. Students interviewed following an in-house outreach indicated that the combination of hands-on discovery activities and an in-depth tour of the NHMFL changed their perceptions of science and scientists. Several respondents indicated a desire to work in a facility such as the NHMFL and also indicated that without the experience, they would not have done the hands-on activities because of a lack of resources at their school.

a5. Tours. Over 12000 students, teachers, and general public have toured the NHMFL facility. A distinguishing feature of these tours that affects how the public perceives the laboratory is the guides that conduct the tours. Since the NHMFL is a working science research facility, guides are volunteers representing every facet of the laboratory: scientists, researchers, graduate students, secretaries, administrators, etc. This interaction with laboratory personnel as they take tour groups around the facility, along with seeing researchers, scientists, and laboratory personnel doing their work is a valuable educational tool. Whether it is children or adults who come to the laboratory, they are always impressed by the fact that they get to see scientists doing what they do every day. Interviews with students revealed that their perception of how science is done in a real-world situation is very different from what they had imagined. Also, the way scientists

(a) Involving stakeholders (continued)

work as a team is a theme that shows up in interviews and surveys. Cultural diversity is another outstanding feature that has been commented on by students, teachers, and others as they observe people from all over the world working in all parts of the facility.

a6. Workshops and Professional Development Opportunities. 150 teachers and teacher trainers attended a series of workshops conducted by NHMFL personnel that covered a wide range of topics, from curriculum products to pedagogical issues. Each workshop had built into it a tour of the facility as well as use of educational technology in the resource laboratory. Evaluations were 100% positive. Teachers enthusiastically endorsed the workshops and asked for more, indicating that the context of the laboratory strongly influenced how they think about science and scientists. Comments such as the following were common: "Show us how [to do hands-on science] and we'll try it!" "I didn't even know NHMFL existed. I feel very fortunate to have signed up for this conference." "This is a great resource to learn about science and technology; it needs to be better utilized by the schools." "This exposes students and teachers to REAL science."

a7. School/Organization Partnerships. The NHMFL works as an active partner with two science museums, the Odyssey Science Museum in Tallahassee, Florida, and the Orlando Science Museum in Orlando, Florida. It is a participating member of the Community Classroom Consortium which brings together representatives from various university, government, private, and public agencies to find ways to enhance science teaching and learning. Membership on School Advisory Councils, which is one agent of change at the school level, allows local schools to take advantage of educational expertise.

a8. Community events. The NHMFL and K-12 personnel take part in a number of community events that attract thousands of visitors to this area. Springtime Tallahassee,

(a) Involving stakeholders (continued)

Kids' Day, the North Florida Fair, Big Bend Regional Science Fair, Big Bend Regional Brain Bowl, as well as numerous other regional activities are supported by the NHMFL. Correspondence from organizers of such activities indicates the high level of respect in which the NHMFL is held by outside organizations. Involvement with such programs creates a connection with the community that results in the general public viewing the laboratory as an integral part of the community in which it is located. Interview respondents indicated that seeing representatives of the laboratory at such functions is an indication that the NHMFL is approachable as a resource. Results also show some stronger indications of how these events and interactions have changed the stakeholders' views and understanding of science, not just their view of the NHMFL.

a9. School events. Science fairs, science expositions, brain bowls, parent nights, faculty meetings, and faculty inservice events are regularly supported by laboratory personnel. Schools are comfortable with calling the NHMFL and asking for help from scientists, researchers, and other personnel with their events. School programs for drop-out prevention, mentoring of below grade level students, and helping in the classroom with science projects are regular requests for the laboratory. Students and teachers have indicated, through responses in interviews and correspondence, that this connection effectively bridges the gap between the science community and the general community. Students have indicated that this contact has taught them that a science research facility represents a place that they could eventually work. This fact alone points up an understanding of what a science research facility is and who works there. When students see the connection, they go out of their way to ask and answer questions about the science

(a) Involving stakeholders (continued)

that is done in such a facility. It also promotes a broader understanding of science as well as enhances the learner's understanding of science content and processes.

a10. Mentorships, externships, and internships. The NHMFL has a number of programs in place for students ranging in grade level from middle school through graduate school at the university level. Interview respondents indicated that the mentorship experience provided unexpected benefits for them from an increased knowledge of subject matter, altered perceptions of scientists, to employment opportunities that were created because of their participation.

a11. Business partnerships. EURUS, an international corporation, came to Tallahassee because of the NHMFL. They are the first cooperative corporate partner with a national laboratory. Manufacturing superconducting wire, EURUS is a safe, nontoxic industry that adds to the area's economic base, creating jobs and attracting other such industries. Interview responses indicate that other partnerships have been established between EURUS and local universities as well as the open exchange of information and technology between the company and the NHMFL. Through interview responses, EURUS personnel expressed the belief that students can be influenced by the manufacturing connection as well as the laboratory connection, each one attracting a different type of student.

a12. Legislation reports and meetings. Being the state capital, Tallahassee is often the site of governmental committee meetings; many times these meetings are held at the NHMFL. The context in which these meetings take place influences participants' attitudes toward the scientific community. When members of the Governor's Commission on Education meet at the NHMFL, they never cease to mention the connection between

(a) Involving stakeholders (continued)

students, schools, and teachers and research facilities such as the NHMFL. Questions are asked as to why facilities such as this one are not taken advantage of by students and teachers. Members of such commissions represent the entire state; as they ask themselves this question, they cannot help but make the connection between other such facilities and schools.

a13. State Department of Education and local boards of education. The NHMFL has undertaken several collaborative projects that resulted in a new curriculum product on magnets and magnetism as well as a number of teacher workshops. Working through state Area Centers for Educational Enhancement, 200 curriculum packages were distributed to middle schools around the State of Florida. Surveys indicate that trainers that took part in the initial distribution of the package and teachers who participated in area workshops think that a science facility has the potential to create new, innovative curriculum products. Respondents indicated that teachers and trainers alike view the science research facility as an expert resource upon which they can depend. Comments implied that maintaining the connection between the public schools and the laboratory could make a difference in how teachers and students view and use curriculum materials.

a14. Local workers at the NHMFL. Daily interactions with K-12 Program personnel, students, teachers, and members of the general public who tour the laboratory, have made a difference in the level of understanding on the part of those who work at the laboratory. Interviews indicate that scientists and technical support personnel have an increased understanding of teaching and learning of science. Not only do NHMFL personnel interact with educators from K-12 Programs, but by participating in events such as tours, teacher workshops, and the Open House, scientists and others from the laboratory

(a) Involving stakeholders (continued)

meet teachers and students. Teachers discuss issues and content questions with scientists at the same time relating how these concepts translate in the classroom. As scientists ask and answer questions, they become more aware of the many issues with which teachers and students have to deal in the course of a normal school day or week. This increased understanding has also translated into changes in classroom practice in the upper level university courses that are taught by NHMFL scientists. Interviews also provide evidence for the fact that scientists rethink their own way of thinking about science as they translate difficult concepts for teachers and students. One scientist who designs and builds resistive magnets finished his interview by looking through his resource material to relearn a theorem he was attempting to use as an example. This renewed enthusiasm for taking the complex and attempting to simplify it was, according to two interviewees, an exercise for which they were appreciative.

a15. University courses. The laboratory has an affect on university courses in two ways. First, K-12 Educational Programs personnel teach both graduate and undergraduate classes at Florida State University in the College of Education. Each of the instructors brings with him or her a unique perspective on teaching and learning based not only on their experience as teachers and students, but as educators who are work closely with scientists at a research laboratory. This perspective has been appreciated by students and has informed the instructors' practice as well. Second, many scientists at the laboratory are also professors at the university. They teach a variety of graduate and postgraduate classes both on campus and at the laboratory. The internationally known scientists that were attracted to Florida State University because of the laboratory have attracted students to Tallahassee that would otherwise have gone to other institutions. Both interviews with

scientists and students have revealed that the courses offered are more desirable, instructors and professors provide a unique perspective through which to view science teaching and learning, and the atmosphere of a world-class facility affect students' ways of looking at science and science teaching and learning.

(b) Providing links. Both the K-12 Educational Programs and the NHMFL in general provide a number of events and programs that link the stakeholders to the laboratory and to one another. According to evidence gathered from interviews, surveys, workshop evaluations, newspaper articles, and internal NHMFL documents, stakeholder groups report changes in attitude about science and scientists and the desire to transfer that knowledge to additional groups. This desire to pass on what has been learned to other members of stakeholder groups translates to a change in perspective on the part of the general public which the authors believe translates to changes in the classroom.

In addition to the events and programs described in the section on involving stakeholders[2], two other programs have a direct influence on stakeholders' ideas of ownership and changing their conceptions and beliefs about science. The two are the Ambassador Program and the availability of an Educational Resource Laboratory.

b16. The Ambassador Program provides an opportunity for educators from a three-county area, from all levels of education, to interact, discuss important issues in education as well as compare ways of teaching and learning science. Among the several items that are covered at Ambassador Meetings, the most important is ways in which teachers and students can become involved at the laboratory and ways that the laboratory can enhance classroom teaching and learning. Interviews, surveys, and discussions and written

[2] The same numbers were used for coding, but with the prefix b.

(b) Providing links (continued)

examples of brainstorming from Ambassador Meetings indicate strongly that this networking opportunity provides a link among stakeholders that would otherwise not exist. Community organizations with an interest in science and science education for the population in general are involved with the Ambassador Program which expands its scope and gives the program credibility among groups other than classroom and school-based educators.

b17. The Educational Resource Laboratory is a fully-equipped multi-media laboratory provided and staffed for classroom teachers and students in particular. The laboratory is open to NHMFL personnel and the general public as well and is heavily used for school groups, teacher workshops, university classes, summer mentorships, curriculum review and materials development. Workshop evaluations, interviews, and follow-up surveys indicate that providing this service (a laboratory manager an extended hours) and facility shows that this research laboratory is serious about supporting education at all levels. The existence of the Educational Resource Laboratory alone has proved to the education community that the NHMFL is seriously committed to the process of education. It has proven to the community at large that the laboratory is a place that is accessible and open to a variety of individuals and groups.

(c) Providing resources. The NHMFL has an extensive outreach as far as materials, equipment, manpower, and information and technology sharing is concerned. Following is a description of some of the resources that are offered to educators and the general public as a part of the mission of the NHMFL. These resources were identified as support for involving stakeholder groups in the laboratory based upon input from interviews, surveys, evaluations, and follow-up surveys and evaluations associated with

(c) Providing resources (continued)

specific curriculum products. News media reports were also analyzed to determine the extent to which the resources provided went beyond the group(s) for which they were intended.

c1. Curriculum materials. K-12 Educational Programs developed curriculum materials for all levels. MagLab: Alpha is a complete package with which to teach and learn about magnets, magnetism, and related concepts. It is designed for use in the middle school classroom but activities have been adapted for both elementary and high school. Results of surveys, evaluations, and interviews indicate that classroom teachers are excited about new curriculum products and in this one specifically because of its association with the NHMFL. Plans are being made to market this product nationally and it has already been distributed to 200 classrooms in the State of Florida. Educators have expressed, through surveys and interviews, the desire for more curriculum products.

Activity books for primary students have been created by K-12 Programs to enhance young students' understanding of the laboratory, magnets and magnetism, and the role of scientists. They are distributed to K-3 students at in-house outreach programs and school-based outreach programs since they are designed to be used with groups too young to tour the laboratory. A second activity book for intermediate students was recently created but has not yet been distributed. Survey data indicate that activity books have created a link between young students, their parents, and the laboratory that otherwise might not have been there. Interviewees stated that any resources provided by the NHMFL are perceived as being "good" resources because of their connection with a research laboratory.

(c) Providing resources (continued)

After making arrangements to visit the laboratory, school groups are sent a pre/post packet of activities and information for use in their classrooms. The intent of the materials is to make the tour more meaningful for students and teachers. Touring a working science facility is an unusual opportunity; understanding what takes place at that facility is a way of better understanding science and scientists. Knowing what to look for has been helpful for both teachers and students, according to interview and survey data. School ambassadors have indicated that these packets have been particularly helpful when planning fieldtrips since it is also material that can be used to justify expenditures of time and money by schools.

c2. A variety of web-based resources are available for students, teachers, and the general public. There is an on-line activity book and a number of student activities posted on the K-12 Educational Programs web site. Both teacher groups and students have indicated in surveys and interviews that they use these resources and find them quite helpful. An Ask The Expert site allows students in classrooms all over the world to ask questions about magnets and magnetism. A Virtual Tour encourages anyone who accesses the site to find out what kinds of research are being done at the laboratory. Students can get help with experiments, find a list of recommended science fair projects, or just satisfy their curiosity about the laboratory by accessing the web site. Teachers in rural areas, interview results show, appreciate this option and feel less isolated because of the accessibility of the laboratory.

c3. Teacher education. One of the most important resources that is provided by the NHMFL through K-12 Educational Programs is teacher education. A series of workshops for elementary and middle school teachers has provided activities, insights, networking

(c) Providing resources (continued)

possibilities, technical training, and resources for 150 plus teachers. That number increases dramatically if the inservice training and professional development workshops implemented by trainers that were part of a "training the trainers" 3-day session are included. Post workshop evaluations, surveys, letters, and samples of student work provide evidence that this is an important component in involving stakeholders. Teachers translate their experiences at the laboratory into new and exciting activities for their students.

The Ambassador Program is a valuable resource for teacher networking. Collegial conversations and meeting colleagues outside of the school setting has proved to be, according to interviews and surveys, an opportunity for which teachers are grateful. As a resource for promoting professionalism among educators, the Ambassador Program has proved successful.

c4. Student education. The NHMFL is involved with students from all levels of education up to and including postdoctoral students. For the purposes of this paper, however, the discussion is limited to K-12 students and the opportunities that they have to interact with scientists, educators, and laboratory personnel. Middle school students participate in a mentorship program with scientists and researchers providing enriching experiences. Gifted public and private school students perform a variety of tasks from creating multimedia presentations to creating computer graphics, to working in laboratories assisting scientists with their research. Students see science as a viable career choice as they work through projects that they help design based upon areas of interest and talent.

Students come to the facility to use the Educational Resource Laboratory; to learn new ways of presenting information in their classrooms. This is an opportunity to use

(c) Providing resources (continued)

skills they already have and learn new ones with the help of K-12 Programs or other researchers. Some students, after their initial exposure to the laboratory, create mentorship and part-time work opportunities with individual researchers. Interviews with students indicate that the mentorships have been the catalyst for other mentorships; that the experience has helped students use talents and skills that otherwise would not have been valued in the traditional classroom; that science is now a career alternative that previously would have seemed too remote.

Outreach and tours, already described in the section on involving stakeholders, have reached over 12000 people. Of this number, surveys and interviews provide evidence that this was the first exposure many of these people have had to a working science research facility. When questioned as to whether they could see themselves as working in such a facility, more people answered yes after outreach or a tour than answered yes before they knew what the NHMFL was.

c5. Advisory role. The NHMFL is involved with a number of organizations that promote educational opportunities in the community. Each organization provides a link with other programs and departments that attempt to involve stakeholders by providing resources. Examples of those organizations are the Community Classroom Consortium, Odyssey Science Museum, the Department of Education, Department of Energy, Department of Environmental Protection, Florida State University, and the Orlando Museum of Science and Technology. The laboratory interacts with each organization in a different way from providing meeting facilities to advising on matters dealing with science and education.

(c) Providing resources (continued)

K-12 Educational Programs is directly involved with the local school board in an advisory capacity, creating new ways to promote science education to students and teachers by designing and implementing teacher workshops and assisting with issues of professionalism and continuing education. In addition, serving on School Advisory Councils provides a direct link between the NHMFL and individual schools. The NHMFL partnership with several schools in the community has been a fruitful one for both partners according to survey data, interview information, and letters and samples of student work.

Infrastructure and resources for community and business. Conference rooms, seminar rooms, audiovisual equipment, computer equipment, laboratory space, and technology equipment and expertise are services that the laboratory provides for community members, organizations, and local and visiting business men and women. Community and business groups that use the facilities at the NHMFL also take advantage of tours and interacting with scientists, researchers, engineers, technical personnel and educators. Interview results with community members who have taken advantage of these facilities provide insight into how the community views the laboratory. It is clear from comments in interviews, surveys, and correspondence, that the facility is a desirable one that carries with it a certain amount of prestige that translates into increased involvement.

c6. Providing manpower. Laboratory personnel are involved in a large number of local charities and charitable events that put together scientists and researchers and members of the general public. Octoberfix, where people from all over the city of Tallahassee come together to repair and renovate older homes, is one such example. Involvement with school groups and civic groups, serving as guest speakers at university functions, teaching classes at the university, judging science fairs at local schools, and mentoring students both

at the laboratory and at schools are some examples that were cited by laboratory scientists, researchers, and personnel on surveys and in interviews.

(d) Influencing policy. The last of the four ways in which a science research institution can influence educational reform is by being aware of policies that affect the work the laboratory does, educating teachers and the general public about policies that affect education, and writing policy on the local level.

By serving in an advisory capacity in both governmental and nongovernmental agencies, the NHMFL maintains a connection with policy-making and decision-making bodies outside of the science community. Documents, evaluations, and surveys reviewed for this paper revealed that curriculum products created by the laboratory affect how curriculum products in general are used at the school level. Because the NHMFL is seen as a "premiere" facility and is internationally renowned for promoting science, it carries considerable influence in the educational community, particularly the regional community. There are several examples where the laboratory's endorsement has pushed through a policy.

The fact that the Academic Resource Center[3] (ARC) continues to operate is an example of the NHMFL influencing local school board policy. Without input and active lobbying by the NHMFL, it is likely that the ARC would have ceased operation. That it is still offering classes (and will continue to do so) is because of the intervention of personnel from the laboratory.

Additionally, in the curriculum resources that have been developed at the NHMFL, because a "real science facility," with the support of industry, is promoting and following

[3] A separate facility for enhancing the education of students identified as gifted in Leon County. The ARC attracts students from both public and private schools, providing enrichment classes 1 day each week to each school.

(d) Influencing policy (continued)

the vision of education portrayed in the National Science Education Standards, policymakers are influenced to follow suit. Further curriculum development is planned with the encouragement of state and local policymakers.

d1. Working with the local school board creating and developing professional development opportunities, such as workshops for a particular purpose or workshops on integrating mathematics and science in the elementary classroom, encourages teachers and facilitators to identify new ways to enhance teaching and learning.

d2. Supporting grants written by local schools, other universities, or individuals expands the range of opportunities that each of these grant-writing institutions has to offer. Additionally, grants involving the NHMFL provide vehicles through which the laboratory can share technology and information with a wide audience.

d3. According to data gathered, laboratory events, special meetings, and publications describe programs and products to a national and international audience. These connections expand the mission of the laboratory in ways that would otherwise have been overlooked. Students from all over the world have access to the laboratory through its web site.

d4. Nationally, students apply for the summer internship program for women and minorities.

d5. Meetings highlighting the research attract scientists and researchers from all over the world; publications are sent out publicizing these meetings to a worldwide audience. Interviews with members of the business community indicate a belief that these types of interactions expand the scope of the laboratory and the businesses.

CONCLUSIONS

Surveys generated by the K-12 Educational Programs personnel, in consultation with experts in survey development, provided a larger group for study than would normally be accessible at the laboratory. Several surveys were distributed at different times throughout the year. Each survey targeted a different stakeholder group in an attempt to represent a wide variety of community members, students, and teachers. Surveys were mailed out to some groups, completed with the researchers by another group, and completed as part of NHMFL functions by yet another group. We were comfortable that the survey results were representative of all stakeholder groups.

Interviews, both individual and group, provided a unique look into how and why the laboratory is able to make a difference in stakeholders' lives, both from a personal and business point of view. The interview technique allowed researchers to probe for depth of meaning to answers and questions. Asking questions when an interviewee mentioned a way that the laboratory interacts with them that had not been anticipated was a technique that provided valuable information.

The reviewed artifacts were so many and varied that, taken together, they provided an in-depth look at what really happens between and among the stakeholders at a great many levels. Each artifact that supported one or more of the four identified ways that a science research institution can facilitate educational reform provided fuel for the fire. Not only did the data sources for this research provide valuable information for this study, they provided an in-depth look at what is done by the NHMFL in general. The study allowed us to take a look at whether the programs that we are offering make a difference or not.

We concluded, after reviewing all of the above data sources, that this particular science research institution, the National High Magnetic Field Laboratory, can be an agent

of reform in education if it does all four of the identified factors of reform. This study has looked at all four facets of educational reform facilitation together. We did not consider each one alone and are operating under the assumption that a science facility such as the NHMFL must do all four to accomplish its mission.

Involving stakeholders, providing the means through which the stakeholder groups take ownership of the facility itself and the work that takes place within it, changing stakeholder beliefs and conceptions of science and scientists, is done on a conscious level. Certain mechanisms that we have identified in this paper must be in place in order for this to happen. Without those policies and procedures, events and programs, the links are not created; the involvement is then only between two parties. Creating links among the stakeholder groups pushes the connection further to create a wider sphere of influence. Now, not only are the stakeholder groups part of the laboratory, but they are involved in each of the group's activities as well. This involvement helps build a sense of community with the science research facility as an integral part of that community. Providing resources in the form of materials and expertise so that the stakeholders continue to look upon the science research facility as a source of valuable information and technology is an integral step in the public perception of the facility as an agent for change.

No one of the four identified attributes of a science research facility as a facilitator of educational reform can on its own produce measurable effects on how teaching and learning is done in schools and outside of schools. The four ways of involving the whole community, regardless of level of education, knowledge of science concepts, or level of interest in science, must be present. Educational reform, however, is a gradual process. It is not inferred here that if a science research facility were to adopt some of the programs

that were implemented at the National High Magnetic Field Laboratory that it would automatically become an agent of reform. The implication is that a science research facility can become one agent of change if the community is involved in the facility and sees it as a part of the community. Tyack and Cuban warn against expecting too much from efforts to reform education: "Lest they, like their predecessors, become "too intramural" and thereby neglect public understanding and participation, reformers who want to change the grammar of schooling today need to enlist the support of parents, school boards, and the community more generally" (1995, p. 109).

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